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ABSTRACT

This paper identifies educational implications that arise from materials collected by James Campbell and his colleagues on the winners of the Mathematics Olympiads. This paper addresses two questions: (1) how can we ensure support for recognized mathematical talent through schooling to professional life, and (2) how can we increase the pool of gifted students who participate in the Olympiads and other excellent competitions and programs? The response to the first question is presented by exploring the following dimensions of talent development: age at which mathematical talent is manifested, role of parents in nurturing children's abilities, curriculum and ambiance of the secondary schools, opportunities for competition and challenge afforded by the Olympiad, underrepresentation of females on the teams, and post-secondary experience of America's most talented students in mathematics and science. The second component of the paper addresses how and why schools should expand the number of students who participate in mathematics and science competitions, including a rationale for the role of talent development in schools; the requisites for talent development, including whether broad or narrow curriculum for secondary students should be pursued; and how we can "plug the leaky pipeline" leading to mathematics-based careers. Contains 59 references. (MKR)

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Implications of the Olympiad Studies for the Development of Mathematical Talent in Schools

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IMPLICATIONS OF THE OLYMPIAD STUDIES FOR THE DEVELOPMENT OF MATHEMATICAL TALENT IN SCHOOLS

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Introduction

Recent manifestations of gifted and talented education have focused on the development of domain specific talent (Feldhusen, 1995; Gagne, 1995), and both longitudinal and retrospective studies have been conducted in order to explore the variables that lead to fulfillment of great potential within each of the domains (Subotnik & Arnold, 1994). James Campbell and his colleagues present longitudinal and retrospective data on the backgrounds and experiences of Mathematics Olympiad winners from three countries: the United States, China, and Taiwan, providing insights into educational and child rearing patterns that enhance or create obstacles for these extremely able youngsters. In this chapter we will identify educational implications that arise from the materials collected by Campbell et al on the American winners. Our discussion will address two lines of questioning: (1) How can we ensure support for recognized mathematical talent through schooling to professional life, and (2) how can we increase the pool of gifted students who participate in the Olympiads and other excellent competitions and programs?

Our response to the first question will be presented by exploring the following dimensions of talent development:

-the age at which mathematical talent is manifested,

-the role of parents in nurturing children's abilities,

-the curriculum and ambiance of the secondary schools,

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-the opportunities for competition and challenge afforded by the Olympiad,

-the underrepresentation of females on the teams, and

-the post-secondary experience of America's most talented students in mathematics and science.

The second component of our paper will address how and why schools should expand the number of students who participate in mathematics and science competitions. This discussion will include a rationale for the role of talent development in our schools, the requisites for talent development, including whether we should pursue broad or narrow curriculum for secondary students, and how we can "plug the leaky pipeline" leading to mathematics-based careers.

<u>At what age should talent development begin?</u>

Each talent domain has its own trajectory (Baldwin, Colangelo & Dettman, 1984; Lehman, 1953; Piirto, 1992; Simonton, 1994; Subotnik, 1995). Prodigious performance in some arenas like mathematics, music, chess, and dance can appear early. When it does, disciplined practice and exposure to incrementally challenging material prepares talented individuals to participate maximally in the creative aspects of a domain, as well as to compete with others in contests and award competitions. Tragically, too many potentially gifted students are held back from learning mathematics at a pace and depth appropriate to their intellectual level. This situation is derived from school policies that are driven by financial constraints, misplaced concerns about equity, poorly conceived curriculum, and under-

prepared teachers.

Whenever a boy or girl expresses interest in pursuing a mathematical topic or moving more rapidly through the curriculum, the opportunity should be made available. Grouping students into an advanced or accelerated math program inoculates them from the lure of anti-intellectual school culture and helps to provide a peer group that makes staying in the advanced track attractive (Miserandino, Subotnik, & Ou, 1995) . Those classes can then serve as the pool for math team and Olympiad membership.

International differences exist in the proportion of Olympians enrolled in gifted programs during their pre-collegiate years. Forty-three percent of the Americans were identified and placed in these programs as early as elementary school, yet, only 14% of similarly aged Taiwanese and no Chinese students chose or were offered that opportunity. By the time they reached high school however, fully 75% of the Taiwanese Olympians and 65% of the Chinese Olympians were enrolled in special gifted programs. The percentage of US students picked up between elementary and secondary levels was only 14%, with a total enrollment of 57% at the secondary level. We speculate that in China and Taiwan, the math curriculum offered to all students in the early years might be rigorous enough to keep young children sufficiently challenged. In the US, many elementary school teachers are not proficient mathematics instructors, and providing instruction beyond arithmetic is rare. Only special gifted programs afford a level of mathematics training sufficient to prepare students for

competition.

According to Bloom (1985), a successful talent development program includes three stages. The first is the romance period, during which children fall in love with a domain. The second stage exposes youngsters to techniques and rules. It is a time for practice, discipline, acquisition of expertise, and testing one's level of proficiency via competition. Some adolescents lose their commitment to a talent area at this point on the continuum. A peer group or team of similarly interested individuals can counteract this movement by providing social support that reinforces continued participation in a specific domain at this crucial juncture (Astin & Astin, 1992). This is especially important for mathematically talented females who are more likely to continue advanced study of mathematics if other females are present in classes (Casserly, 1980; Casserly & Rock, 1985) or on teams. The third stage of talent development is associated with refining a style and developing a niche. Olympiad students might experience this educational interaction with their graduate school mentors.

Parental support for the talent development process

For many Olympiad winners, the talent development process began at home. Neither the Olympiad winners nor their parents reported that excessive pressure was placed on the winners to achieve highly. Clearly, there were sufficient intrinsic rewards emanating from participation in the competition to preclude the need for much parental influence. Parents may play more of a

support role like driving students to competitions, providing verbal encouragement, or helping children to manage time and other commitments. Youngsters who derive pleasure from intellectual activity are good candidates for socialization into the world of academic science and mathematics, where status and life satisfaction are based on immersion in the life of the mind.

Parental commitment is crucial to the development of these values, yet monitoring the quality and amount of involvement can be difficult. When the attitudes, values, and experiences that students bring with them from home are congruent with those of the mathematics coach or team leader, the combination is dynamic. However, when they are counterproductive, the result can be student burnout or attrition from the mathematics fast-track.

Greater collaboration between parents and the school assures that students capable of such high levels of performance receive the support required for a rigorous competitive process. The education community must maintain parental connections through all levels of schooling, especially during the secondary years when parental involvement is most likely to drop off. In the United States, the transition from elementary school to high school is a critical crossroad in student academic and personal achievement.

The school environment

In 1995, 5,495 high schools participated in The 46th American High School Mathematics Examination (AHSME), a 2.2% increase over the previous year. Although the number of

contestants (354,420) increased 4% from the previous year, this number represents only 2.4% of high school students in the US. The percentage of females sitting for the AHSME has remained stable in recent years at approximately 45%.

At least the number of high school students enrolled in the 1995 AHSME is significantly larger than that of the preliminary math competition, The American Junior High School Mathematics Examination (AJHME). The 1995 AJHME competition included only 199,314 students in grades 5-8. The lower levels of participation in the AJHME compared to the AHSME may be attributed to the wide variability of what is offered to students as a result of debates over curriculum reform.

The pipeline can be said to increase its flow 78% from the junior to the senior levels of mathematics competition. This increase may reflect the recent commitment of schools to further enrich opportunities for students in the areas of science and mathematics. For example, many of the awards given by the Department of Education under the auspices of the Javits Gifted and Talented Act have been targeted at increasing girls and other under-represented groups' interest and success in mathematics and science. In addition, the National Council of Teachers of Mathematics has taken a very active role in encouraging increased participation in math competitions and in raising national standards for mathematics achievement (NCTM, News Bulletin, March 1996). Recent studies on single sex education (Subotnik & Strauss, 1995), the role of mentoring (Arnold & Subotnik, 1995),

and the benefits derived from domain specific homogenous grouping (Miserandino, Subotnik, & Ou, 1995), offer interventions to support more successful participation by females and other underrepresented groups in mathematics.

These programmatic initiatives must be expanded into the elementary schools so as to channel more students into mathematics and science extra-curricular activities such as competitions and clubs. Increasing the involvement of parents in this effort through programs like Family Math enhances the potential for early identification of talented students and the likelihood that families will view mathematics as both useful and creative (Steinmark, Thompson, & Cossey, 1986).

Not all the Olympiad winners were in special school programs. However, participating in the Olympiad process allowed for opportunities to meet, compete, and compare oneself with other very bright students who shared a deep interest in mathematics. Membership in a group that values intellectual and academic pursuits can be especially important in schools where the climate is distinctly anti-intellectual. Students who experience being ostracized or harassed by classmates can find comfort in the company of fellow Olympiad participants.

According to social comparison theory (Festinger, 1989), students develop their academic self concepts by contrasting their abilities with those around them. If students perceive themselves to be the most skillful mathematics students in the school for most of their school careers, their academic self-

concepts are likely to be very high. However, without competition or great intrinsic motivation, they are less likely to know the full extent of their capabilities. Learning to equate effort with achievement is an important lesson too often missed by those who are never sufficiently challenged, and results in the belief that anything requiring discipline or persistence is "boring," or indicative of mediocre ability.

Finally, schools can increase student involvement with mathematics through staff development. This can be accomplished in three ways: attending to the in-service needs of teachers (Ball, 1993; Lampert, 1990); changing faculty culture regarding attitudes toward mathematics instruction, grouping, and acceleration (Cobb, 1994; Peterson & Barnes, 1996; Resnick, 1989); and developing collaborative relationships with university-based teacher education programs. The focus of professional development should be on both increasing teachers' level of competence in mathematics and their knowledge about how to identify and develop mathematical talent. Linking professional development with university collaborations will also provide opportunities for teachers to gain greater competency in mathematics, creating for them a larger "community of learning" and support network (Miserandino, Subotnik, & Ou, 1995; Peterson & Barnes, 1996). This community can especially broaden the success of the talent development experiences like the Olympiads for mathematically gifted students not yet being served. The biggest pool of untapped talent is that of girls, who are not

succeeding at the very top levels of the competition.

Increasing female participation

Gender differences in secondary mathematics achievement have been diminishing except among the mathematically most talented (Benbow & Stanley, 1983; Callahan, 1991; Coley, 1989; Finegold, 1988; Linn & Hyde, 1989; Wilder & Powell, 1989). A body of literature has been accumulating to explain these results.

Female under representation in the ranks of international level Olympiad winners is notable. There were only two female participants in the entire history of the American Olympiad team, and no African-Americans or Latinos. Schools, families, and female students themselves must contemplate the sources of girls' lack of participation. Course placement and selection in secondary and middle schools certainly has an impact on exposure to and challenge from mathematics content. By the end of high school, boys substantially exceed girls in the number of math courses taken (Astin, 1993). Girls are also less likely to hold high expectations for their success in highly demanding mathematics environments (Lent, 1991), even when ability differences are not apparent (Betz & Hackett, 1983; Campbell & Beaudry, 19XX). Lowered self-concept in mathematics is associated with fear of trying alternative solutions or shortcuts, preferring to follow "recipes" or fixed sequences of problem solution (Grieb & Eisley, 1984; Linn & Hyde, 1989; Mura, 1987; Wilder & Powell, 1989). Given that secondary school mathematics grows increasingly complex, competent math learners

need to operate comfortably with mathematical principles at each grade level to avoid relying on memorized formulas (Blais, 1985; Davis, 1984; Schoenfeld, 1985), to think flexibly, and to make broad and rapid generalizations (Krutetskii, 1976). Clearly, in order to become more autonomous learners, a key to expertise and creative productivity in mathematics, females must engage confidently with the challenge of mathematical problem solving (Campbell & Beaudry, 19XX; Fennema & Peterson, 1985).

Too often adolescent girls remain unconvinced that mathematics and science will be useful to their long-term goals (Linn & Hyde, 1989). In fact, according to the literature exploring gender differences in science and mathematics achievement and retention, males tend to value mathematics and science more dearly than females, particularly beyond the elementary school years (Betz & Hackett, 1983). Females who are highly talented in both verbal and mathematical areas are more likely to choose non-quantitative rather than quantitative college majors and career fields (Lubiniski, Benbow, & Sanders, 1993; Stocking & Goldstein, 1992; Olszewski-Kubilius & Yosumoto, 1995). Their choices for summer enrichment programs reflect a clear preference for verbal subjects.

Teacher behavior and student-teacher interaction is another potential influence on gender differences in mathematics achievement. The largest number and highest quality of teacher interactions in mathematics and science classrooms have been reported to take place with a small number of students, most

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often high achieving males. Further, female classmates and peers exert pressures to value popularity over commitment to academic excellence (Smith, 1992). Male students may believe mathematics is more a male domain (Olszewski-Kubilius & Wohl, 1993) and therefore females are less able to participate in advanced work in the area. The classroom environment, therefore, has been found to encourage males and to discourage females from achieving excellence in mathematics (Becker, 1981; Good, Sikes & Brophy, 1973; Hart, 1989; Karp & Yoels, 1976; Orenstein, 1994; Sacker, Sacker & Long, 1989; Tobin & Gallagher, 1987).

Urging students, particularly females, to take a stab at a problem by welcoming educated guesses, or by encouraging students to work together in small groups composed of more than one girl in each group, may assist in increasing females' confidence in their mathematical prowess (Lockheed & Harris, 1984; Treisman, 1985). A strong sense of self-efficacy makes individuals more resistant to withstand failures and obstacles encountered along the way (Orenstein, 1994).

How Colleges address the needs of students who achieve national or international recognition in high school

The talent development model employed by athletic associations, conservatories, or dance academies offers notably gifted individuals an individually tailored program to enhance their abilities and extend their competitive status, including placement with a special coach or teacher, and a practice schedule created to strengthen needed weak points and feature

obvious strengths. The most able of those admitted to such programs come out identifying strongly with their talent domain, and more able to use their gifts to achieve great performance and creativity.

In contrast, students who achieve great recognition for their abilities in academic domains such as mathematics and science are too often allowed to progress unattended during their first two years of college. They may then choose prestigious institutions that admit students of high caliber in various domains, thus becoming one of many freshmen "stars." Operating without a mentor or someone who can take a personal interest in their progress increases the likelihood that the notoriously unpleasant science/math pedagogy of the first two years (Seymour & Hewitt, 1994) will weed them out. In fact, some members of the 1983 cohort of Westinghouse winners studied by Subotnik and her colleagues (Subotnik, Duschl, & Selmon, 1993; Subotnik & Steiner, 1994) left large and impersonal classes to enjoy the humanities. Since the Olympiad team is composed of only six people, society should ensure that each one of them that wishes to pursue mathematics, science, or technology is guided to the most suitable teachers, peers, and technology in the post-secondary institutions they attend.

Where do the needs of the gifted fit into the current educational climate?

In the history of education literature, a metaphor often used for the public schools is the factory model (Kleibard,

1975). In school, individuals learned punctuality, following directions to achieve prescribed goals, and accepted where they belonged in the academic hierarchy. Children who demonstrated extraordinary aptitude were generally skipped through grades. Only those with the most potential or with the highest socioeconomic levels attended secondary schools.

Today's education reform movement has distanced itself from the undemocratic factory model of schooling by shifting the focus of attention to creating classroom communities, and greater emphasis is placed on social development and skills. How are students with academic talent to be accommodated in this climate of reform? Some regions or localities recognize the special needs of students who are outside the academic mainstream. They maintain or create programs designed to provide gifted students with challenging coursework and peers, allowing them to advance through the curriculum with their age and ability mates. A smaller number of schools follow the earlier tradition of skipping students who demonstrate above grade level mastery. Finally, a growing number of school districts are expecting talented students to share their abilities with heterogeneously grouped classmates and teachers to meet the educational needs of a very diverse group of learners. The main source of resistance to this "detracking" movement is in secondary mathematics. Because of the sequential nature of the material offered in mathematics classes, varying levels of content acquisition and mastery are clearly visible to trained professionals. Secondary

mathematics teachers tend to therefore support ability grouping (Grossman & Stodolsky, 1995). The response to ability grouping at the elementary and middle school levels is much more ambivalent.

Requisites for the fulfillment of talent

Walberg's 9 factor model (1988), described in Chapter 1, enhances our understanding of how the intellectual acuity of the winners interacts with parental, educational, and peer support to result in maximum learning. Tannenbaum (1986) also delineated contributing factors that lead to the fulfillment of a gifted child's promise including: general intelligence, specific talent, environmental support (Walberg's parental, educational, and peer support), conducive psychological characteristics such as high motivation and drive, and chance factors. For different talent domains, different threshold levels of each factor might be sufficient, but all must be in place in order to transform potential into creative productivity or eminence.

General intelligence refers to IQ type problem solving skills. There are no IQ data available on the Olympiad winners, but given their stellar school performance (63.5% were in the top 10% of their class; 24% in the top 1%), one can assume that their IQ's were reasonably high. Specific talent is demonstrated by their recognition as Olympiad winners in mathematics, and competing successfully in the Olympiads exhibits drive and motivation. Parents promoted their children's preparation and involvement, and schools offered the program, and the competition offered valued peers and social support. Finally, chance factors

like the economy influence available sustenance in post secondary education and careers. For example, the 1983 cohort of Westinghouse winners followed by Subotnik et al. (Subotnik & Steiner, 1994; Subotnik & Arnold, 1996) are currently 30 years old. Many of these highly talented and superbly trained individuals are struggling with a tight market for scientific jobs, particularly in academic research, the arena where many dreamed of finding a professional home. Further, their choice of college, often made on the basis of name rather than intellectual fit, and the availability of mentors, have an impact on whether gifted individuals pursue quantitatively based careers.

Narrow vs broad training

Many educators and parents fear that adolescent preoccupation with a talent will hamper youngsters' social development. Bloom's (1985) study subjects spent approximately six hours a day during their school years in practice or study. Preparing for participation in the Olympiad also requires a serious commitment of time on the part of the competitors.

Eminent individuals in every field exhibit rigorous discipline and devotion to the pursuit of excellence (Ochse, 1990; Subotnik, 1995; Subotnik & Arnold, 1995; Subotnik, Kassan, Summers, & Wasser, 1993). Although Olympiad winners were actively involved in many high school activities, they had to sacrifice some dimensions of their lives in the name of successful international competition. In fact, not all the Olympiad winners pursued or expected to pursue careers in science

or mathematics. Participating in the program did not preclude involvement in a liberal arts curriculum or extracurricular activities. The discipline and confidence needed to achieve such a high level of competitiveness in mathematics is certainly applicable to achieving in any high status or creative field.

The science/mathematics pipeline: Where does it begin?

The pipeline leading to deep commitment and interest in mathematics begins in elementary school. Students who are exposed to concepts and topics beyond computation get a much more complex and accurate picture of the discipline. Those students who, for example, find visual/logical reasoning more compelling than verbal/logical reasoning could be engaged by topology, geometry, and some aspects of number theory. Further, teachers who are well prepared and confident in their mathematical learning can enjoy and model creativity in problem finding and solving.

The pipeline starts to leak in middle school when children begin their engagement with abstract reasoning in mathematics. Those who had a rich elementary school experience should be able to adapt well to the challenge. Depending on how a student performs in sixth and seventh grade math, he or she will be placed in an algebra or pre-algebra class, and those who take algebra earlier are more likely to have room for a calculus course before they graduate, opening up opportunities advanced studies in college.

Although reading level is the gauge for determining "smartness" in elementary school, math placement is the key to

determining smartness in the middle and high school. The ramifications for placement in a top level class are great for academic self-confidence. Further, mathematics and the sciences, particularly the physical sciences project an impression of superior academic rigor that can be especially attractive for many intellectually gifted students, boys in particular. At this point, social pressure, gender stereotypes, and competing interests in other domains such as sports, music, and the humanities, may draw talented females and underrepresented minorities from enrolling or being selected into the top mathematics track.

Conclusion

The Olympians are a very select group of students, yet their achievement stands as a benchmark for all gifted students. Clearly, individuals with special interests or talents in mathematics need to be identified as early as possible, and supported and challenged by their teachers throughout their formal school experience. Many lines of inquiry are worthy of pursuit including how the learning that occurs in preparation for the Olympiad exams compares to the instruction received in class.

Research on participants in the International Mathematics Olympiads suggests that the experience of high level competition influences major life choices. Preparation for the Olympiad embeds mathematically talented youngsters within a social context that supports their intellectuality and achievement. The study of those conditions helps to delineate aspects that are

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especially conducive to replication in other settings, in other domains, and with other groups of learners. The Olympiad model generates information with implications for talent development broadly conceived that can contribute to current discussions of school reform and restructuring.

References

Arnold, K.D., & Subotnik, R.F. (1995). Mentoring the gifted: A differentiated model. Educational Horizons, 73, 118-123.

Astin, A.W. (1993). What matters in college?: Four critical years revisited. San Francisco: Jossey-Bass.

Astin, A.W., & Astin, H.S. (1992). Undergraduate science education: The impact of different college environments on the educational pipeline in science. Final Report to the National Science Foundation (grant # SPA-8955365).

Baldwin, C.B., Colangelo, N., & Dettman, D.F. (1984). Perspectives of creativity through the lifespan. Creative Child and Adult Quarterly, 9, 9-17.

Ball, D.L. (1993). With an eye to the mathematical horizon: Dilemmas of teaching elementary school mathematics. Elementary School Journal, 93, 373-397.

Becker, J. (1981). Differential treatment of females and males in mathematics classes. Journal for Research in Mathematics Education, 12(2), 40-53.

Benbow, C.P., & Stanley, J.C. (1983). Sex differences in mathematical reasoning ability: More facts. Science, 222, 1029-1031.

Betz, N.E., & Hackett, G. (1983). The relationship of mathematics self-efficacy expectations to the selection of science-based college majors. Journal of Vocational Behavior, 23, 329-345.

Blais, D.M. (1985). Constructivism: A theoretical revolution for algebra. Mathematics Teacher. 81 (8), 624-631.

Bloom, B.S. (1985). Developing talent in young people. New York: Ballantine.

Callahan, C.M. (1991). An update on gifted females. Journal for the Education of the Gifted. 14, 284-311.

Campbell, J.R., & Beaudry, J.S. (19XX). Gender gap linked to differentiated socialization for high ability 11th grade math students.

Casserly, P.L. (1980). Factors affecting female participation in Advanced Placement programs in mathematics, chemistry, and physics. In L.H. Fox, L. Brody & D. Tobin (Eds.). Women and the Mathematical Mystique (pp. 138-163)). Baltimore, MD: Johns Hopkins University Press.

Casserly, P.L., & Rock, D. (1985). Factors related to young women's persistence and achievement in Advanced Placement mathematics. In S.F. Chipman & D.M. Wilson (Eds.) Women and Mathematics: Balancing the equation (pp. 225-248). Mahwah, NJ: Erlbaum.

Cobb, P. (1994). Where is the mind? Constructivist and sociocultural perspectives on mathematical development. Educational Researcher, 23 (7), 13-20.

Coley, R.J. (1989). The gender gap in education: How early and how large? ETS Policy Notes, 2(1), 1-5.

Davis, R. B. (1984). Learning mathematics: The cognitive science approach to mathematical education. Norwood, NJ: Ablex.

Feingold, A. (1988). Cognitive gender differences are disappearing. American Psychologist, 43(2), 95-103.

Feldhusen, J.F. (1995). Talent development vs. gifted education. Educational Forum, 59, 346-349.

Fennema, E., & Peterson, P. (1985). Autonomous learning behavior: A possible explanation of gender related differences in mathematics. In L.C. Wilkinson & C.B. Marrett (Eds.) Gender influences in classroom interaction (17-35). Orlando, Florida: Academic Press.

Festinger, L. (1989). Extending psychological frontiers: Selected works of Leon Festinger. New York: Russell Sage Foundation.

Gagne, F. (1995). From giftedness to talent: A developmental model and its impact on the language of the field. Roeper Review, 18, 103-112.

Good, T., Sikes, J.N., & Brophy, J. (1973). Effects of teacher sex and student sex on classroom interaction. Journal for Educational Psychology, 65(1), 74-87.

Grieb A., & Eisley, J. (1984). A primary school impediment to math equity: Case studies on rule dependent socialization. In M. Steinkamf & M. Maehr (Eds.) Advances in motivation and

achievement, Vol 2 (pp. 313-362). NY: JAI Press.

Grossman, P.L., & Stodolsky, S.S. (1995). Content as context: The role of school subjects in secondary school teaching. Educational Researcher, 24(8), 5-11.

Hart, L. E. (1989). Classroom processes, sex of student, and confidence in learning mathematics. Journal for Research in Mathematics Education, 20, 242-260.

Karp, D.E., & Yoels, W.C. (1976). The college classroom: Some observations on the meaning of student participation. Sociology and Social Research, 60, 421-439.

Kleibard, H.M. Bureaucracy and curriculum theory. In W. Pinar (Ed.) Currriculum theorizing: The reconceptualists (pp. 51-69). Berkeley, CA: McCutchen.

Krutetskii, V.A. (1976). The psychology of mathematical abilities in children. Chicago, IL: University of Chicago Press.

Lampert, M. (1990). When the question is not the question and the solution is not the answer: Mathematical knowledge and teaching. American Educational Research Journal, 27, 29-63.

Lehman, H.C. (1953). Age and achievement. Princeton, NJ: Princeton University Press.

Lent, R.W., Lopez, F.G., & Bieschke, K.J. (1991). Mathematics self-efficacy: Sources and relation to science-based career choice. Journal of Counseling Psychology, 38, 424-430.

Linn, M. C., & Hyde, J.S. (1989). Gender, mathematics and science. Educational Researcher, 18(8), 17-27.

Lockheed, M.E., & Harris, A.M. (1984). Cross-sex collaborative learning in elementary classrooms. American Educational Research Journal, 21(2), 275-294.

Lubinski, D., Benbow, C.P., & Sanders, C.E. (1993). Reconceptualizing gender differences in achievement among the gifted: An outcome of contrasting attributes for personal fulfillment in the world of work. In K. Heller, F.J. Monks & A.H. Passow (Eds.) International Handbook for Research on Giftedness and Talent (pp. 693-708). Oxford: Pergamon.

Miserandino, A.D., Subotnik, R.F., & Ou, K. (1995). Identifying and nurturing mathematical talent in urban school settings. Journal of Secondary Gifted Education, 6, 245-257.

Mura, R. (1987). Sex-related differences in expectations of success in undergraduate mathematics. Journal for Research in

Mathematics Education, 18(1), 15-24.

NCTM (1996). National Council of Teachers of Mathematics News Bulletin.

Olszewski-Kubilius, P., & Wohl, V. (1993, August). Gender differences in mathematics for academically talented Caucasian and Asian-American adolescents. Paper presented at the conference of the World Council for Gifted, Toronto, Canada.

Olszewski-Kubilius, P., & Yosumoto, J. (1995). Factors affecting the academic choices of academically talented middle school students. Journal for the Education of the Gifted , 18, 298-318.

Orenstein, P. (1994). School girls. New York: Bantam.

Peterson, P.L., & Barnes, C. (1996). Learning together: The challenge of mathematics, equity, and leadership", Phi Delta Kappan, 77, 485-492.

Piirto, J. (1992). Understanding those who create. Dayton, OH: Ohio Psychology Press.

Resnick, L. (1989). Treating mathematics as an ill-structured discipline. In R. Charles & E. Silver (Eds.), The teaching and assessing of mathematical problem solving (pp. 32-60). Reston, VA: National Council of Teachers of Mathematics.

Sadker, M., Sadker, D., & Long, L. (1989). Gender and educational quality. In J.A. Banks & C.M. Banks (Eds.) Multicultural education:Issues and perspectives (pp. 106-123). Newton, MA: Allyn & Bacon.

Schoenfeld, A.H. (1985). Mathematical problem solving. New York: Academic Press.

Simonton, K.D. (1994). Greatness: Who makes history and why. New York: Guilford Press.

Smith, T.E. (1992). Gender differences in the scientific achievement of adolescents: effects of age and parental separation. Social Forces, 71, 469-484.

Stenmark, J.K., Thompson, V., & Cossey, R. (1986). Family math. Berkeley, CA: Lawrence Hall of Science.

Stocking, V.V., & Goldstein, D. (1992). Course selection and performance of very high ability students. Is there a gender gap? Roeper Review, 15, 48-51.

Subotnik, R.F. (1995). Talent developed: Conversations with masters of the arts and sciences. Journal for the Education of

the Gifted, 18, 440-466.

Subotnik, R.F., & Steiner, C. (1994). Adult manifestations of adolescent talent in science: A longitudinal study of 1983 Westinghouse Science Talent Search winners. In R.F. Subotnik & K.D. Arnold (Eds). Beyond Terman: Contemporary longitudinal studies of giftedness and talent (pp. 52-76). Norwood, NJ: Ablex.

Subotnik, R.F., & Strauss, S.M. (1995). Gender differences in classroom participation and achievement: An experiment involving Advanced Placement calculus classes. Journal of Secondary Gifted Education, 6, 77-85.

Subotnik, R.F., Duschl, R.A., & Selmon, E.H. (1993). Retention and attrition of science talent: A longitudinal study of Westinghouse Science Talent Search winners. International Journal of Science Education, 15, 61-72.

Tannenbaum, A.J. (1986). Giftedness: A psychosocial approach. In R.J. Sternberg & J.E. Davidson (Eds.). Conceptions of giftedness (pp. 21-52). New York: Cambridge University Press.

Tobin, K., & Gallagher, J.J. (1987). The role of target students in the science classroom. Journal for Research in Science Teaching, 24(1), 61-75.

Treisman, U. (1985). A study of mathematics performance of black students at the University of California, Berkeley. Unpublished manuscript, University of California-Berkeley, Professional Development Program, Berkeley.

Walberg, H. (1988). Creativity and talent as learning. In R.J. Sternberg (Ed). The nature of creativity (pp. 340-361). New York: Cambridge University Press.

Wilder, G.Z., & Powell, K. (1989). Sex differences in test performance: A survey of the literature. (College Board Report #89-3). New York:College Entrance Examination Board.